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# NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

## TECHNICAL NOTE

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### EFFECT OF VARIATION IN DIAMETER AND PITCH OF RIVETS ON COMPRESSIVE STRENGTH OF PANELS WITH Z-SECTION STIFFENERS

PANELS THAT FAIL BY LOCAL BUCKLING AND HAVE  
VARIOUS VALUES OF WIDTH-TO-THICKNESS RATIO  
FOR THE WEBS OF THE STIFFENERS

By Norris F. Dow and William A. Hickman

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Langley Field, Va.



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## SUMMARY

An experimental investigation is being conducted to determine the effect of varying the rivet diameter and pitch on the compressive strength of flat 24S-T aluminum-alloy Z-stiffened panels of the type for which design charts are available. The present part of the investigation is concerned with panels which have various values of width-to-thickness ratio of the webs of the stiffeners and have such length that failure is by local buckling. The results show that for these panels, regardless of their stiffener widths, the compressive strengths increased appreciably with either an increase in the diameter of the rivets or a decrease in the pitch of the rivets.

## INTRODUCTION

The design and analysis of sheet-stiffener panels for aircraft structures have been the subject of extensive experimental and theoretical investigations, but the determination of the size and pitch of rivets for attaching sheet to stiffener is a problem that has not been adequately solved. In reference 1 charts and procedures are presented for the design of Z-stiffened panels to carry a given intensity of loading at a given panel length. The test data on which these design charts were based, however, were obtained for an arbitrary diameter and pitch of the rivets. An investigation is therefore being conducted in the Langley structures research laboratory of the National Advisory Committee for Aeronautics to determine the effect of a variation in the rivet diameter and pitch on the strength of 24S-T aluminum-alloy panels with longitudinal Z-section stiffeners of the type for which the design charts of reference 1 were prepared.

Four basic variables have been considered in this investigation of the effect of riveting on panel strengths:

- (1) The ratio of stiffener thickness to skin thickness  $t_w/t_s$
- (2) The slenderness ratio  $L/\rho$
- (3) The ratio of stiffener spacing to skin thickness  $b_s/t_s$
- (4) The ratio of stiffener width to stiffener thickness  $b_w/t_w$

The range of values tested for each variable is given in table 1, which also includes the references in which the data are presented.

The results of varying the ratio of stiffener width to stiffener thickness  $b_w/t_w$  are given in the present paper.

#### SYMBOLS

$L$	length of specimen, inches
$\rho$	radius of gyration, inches
$L/\rho$	slenderness ratio
$W$	width of specimen, inches
$b_s$	spacing of stiffeners on sheet, inches
$b_A$	width of attachment flange of stiffeners, inches
$b_w$	width of web of stiffeners, inches
$b_F$	width of outstanding flange of stiffeners, inches
$t_s$	thickness of sheet, inches
$t_w$	thickness of web of stiffener, inches
$d$	diameter of rivets, inches
$p$	pitch of rivets, inches
$h$	depth of countersink for rivets, inches
$\sigma_{cy}$	compressive yield stress for material, ksi
$\bar{\sigma}_f$	average compressive stress at failing load, ksi
$c$	coefficient of end fixity in Euler column formula

$P_i$  compressive load per inch of panel width, kips per inch

R radius of bend

#### TEST SPECIMENS AND METHOD OF TESTING

For all parts of the investigation.- The specimens consisted of 24S-T aluminum-alloy panels having longitudinal Z-section stiffeners as shown in figure 1. The stiffeners were riveted to the sheet with Al7S-T flat-head rivets (AN442AD). In all cases the minimum rivet pitch used was equal to three times the rivet diameter. The rivets were driven by the NACA flush-riveting process in which the rivet is inserted with the head opposite the countersunk end of the hole, the shank of the rivet is driven into the cavity formed by the countersink, and the excess material is removed with a milling tool. A countersink angle of  $60^\circ$  was used.

Ultimate compressive loads for the specimens were determined in a hydraulic testing machine having an accuracy of one-half of 1 percent of the load. The ends of the specimens were ground accurately flat and parallel in a special grinder, and the method of alinement in the testing machine was such as to insure a uniform bearing over the ends of the specimens.

For the present part of the investigation.- Five width-to-thickness ratios for the stiffeners, corresponding to values of  $b_w/t_w$  of 20, 25, 30, 40, and 50, were investigated. (See fig. 2.) Two thicknesses of sheet were used to give two ratios of stiffener thickness to sheet thickness ( $\frac{t_w}{t_s} = 1.00$  and 0.63). The lengths of the panels were so chosen ( $\frac{L}{P} = 20$ ) that no column bending failures occurred. The proportions  $\frac{b_s}{t_s} = 25$ ,  $\frac{b_A}{t_w} = 9.5$ , and  $\frac{b_F}{b_w} = 0.4$  were the same for all panels.

The with-grain compressive yield strength  $\sigma_{cy}$  of the material before forming was found to be as follows: 47.2 ksi (max.), 45.2 ksi (av.), and 44.0 ksi (min.).

#### RESULTS AND DISCUSSION

The results are presented in figure 3 and table 2. In figure 3,  $\sigma_f$ , calculated simply as the failing load divided by the cross-sectional area of the panel, is plotted against the ratio of the rivet diameter

to the sum of the thicknesses of sheet and stiffener  $\frac{d}{t_S + t_W}$  in order to present the results in a manner similar to that used in references 2, 3, and 4. Figure 3 shows that for all values of  $t_W/t_S$  and  $b_W/t_W$  investigated the compressive strengths increased with either an increase in the diameter of the rivets or a decrease in the pitch of the rivets.

These results differ from those of reference 5 in which the compressive strength of Z-stiffened shells was found to change very little with rivet spacing when failure occurred by local buckling of the stiffeners. The panel tests described in reference 5, however, covered an entirely different range of proportions from that of the present investigation. In

reference 5 the proportions covered were such  $\left( \frac{t_W}{t_S} = 2 \text{ or } 3, \frac{b_S}{t_S} = 350 \right)$

that the sheet contributed only a small amount to the load-carrying ability of the assembly. Changing the rivet pitch over the range investigated therein  $\left( \frac{p}{t_S + t_W} = 14 \text{ to } 50 \right)$ , or even increasing it to considerably larger

values of  $\frac{p}{t_S + t_W}$  so that the sheet contributed a negligible load-

carrying capacity, would be expected to produce only small changes in panel strength.

#### CONCLUDING REMARKS

Results are presented of an investigation to determine the effect of varying the rivet diameter and pitch on the compressive strength of flat 24S-T aluminum-alloy Z-stiffened panels of the type for which design charts are available. The present part of the investigation is concerned with panels which have various values of width-to-thickness ratio of the webs of the stiffeners and have such length that failure is by local buckling. The results show that for these panels, regardless of their width-to-thickness ratio, the compressive strengths increased appreciably with either an increase in the diameter of the rivets or a decrease in the pitch of the rivets.

Langley Aeronautical Laboratory  
 National Advisory Committee for Aeronautics  
 Langley Field, Va., September 11, 1948

## REFERENCES

1. Schuette, Evan H.: Charts for the Minimum-Weight Design of 24S-T Aluminum-Alloy Flat Compression Panels with Longitudinal Z-Section Stiffeners. NACA Rep. No. 827, 1945.
2. Dow, Norris F., and Hickman, William A.: Effect of Variation in Diameter and Pitch of Rivets on Compressive Strength of Panels with Z-Section Stiffeners. I - Panels with Close Stiffener Spacing That Fail by Local Buckling. NACA RB No. L5G03, 1945.
3. Dow, Norris F., and Hickman, William A.: Effect of Variation in Diameter and Pitch of Rivets on Compressive Strength of Panels with Z-Section Stiffeners. Panels of Various Lengths with Close Stiffener Spacing. NACA TN No. 1421, 1947.
4. Dow, Norris F., and Hickman, William A.: Effect of Variation in Diameter and Pitch of Rivets on Compressive Strength of Panels with Z-Section Stiffeners. Panels of Various Stiffener Spacings That Fail by Local Buckling. NACA TN No. 1467, 1947.
5. Kromm, A.: Einfluss der Nietteilung auf die Druckfestigkeit versteifter Schalen aus Duralumin. Luftfahrtforschung, Bd. 14, Lfg. 3, March 20, 1937, pp. 116-120.

TABLE 1.- RANGE OF VALUES TESTED FOR EACH  
VARIABLE IN THE INVESTIGATION OF THE  
EFFECT OF RIVETING ON PANEL STRENGTH

$\frac{t_w}{t_s}$	$\frac{L}{p}$	$\frac{b_s}{t_s}$	$\frac{b_w}{t_w}$	Reference
0.51 .63 .79 1.00 1.25	20	25	20	2
0.63 1.00	20 40 70 120	25	20	3
0.63 1.00	20	25 30 35 40 50 	20	4
0.63 1.00	20	25	20 25 30 40 50	Present paper

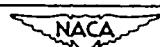


TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS  
SHOWING EFFECTS OF VARYING RIVET PITCH AND RIVET DIAMETER

Diam. of rivets, $d$ (in.)	Depth of countersink, $h$ (in.)	Pitch of rivets, $p$ (in.)	Average stress at failing load, $\sigma_f$ (ksi)	$\frac{P_1}{L/\sqrt{8}}$ (ksi)
$t_s = 0.064 \text{ in.}; b_s = 1.60 \text{ in.}; L = 10.40 \text{ in.}; W = 8.64 \text{ in.}; b_W = 1.28 \text{ in.}; b_p = 0.51 \text{ in.}$				
$\frac{t_W}{t_s} = 1.00; \frac{b_s}{t_s} = 25^a; \frac{b_W}{t_W} = 20$				
1/16	0.035	3/16	43.050	1.233
		3/8	41.450	1.180
		5/8	b36.855	1.013
		15/16	b38.380	1.093
		1 $\frac{5}{16}$	29.300	.840
		1 $\frac{3}{4}$	26.700	.768
3/32	.040	9/32	44.800	1.303
		3/8	b43.500	1.245
		5/8	b38.070	1.069
		15/16	b40.035	1.140
		1 $\frac{5}{16}$	33.400	.950
		1 $\frac{3}{4}$	30.700	.891
1/8	.050	3/8	44.600	1.317
		5/8	b43.735	1.227
		15/16	b41.710	1.186
		1 $\frac{5}{16}$	34.750	.990
		1 $\frac{3}{4}$	32.200	.856
		15/32	45.000	1.318
5/32	.060	5/8	43.870	1.197
		15/16	40.500	1.142
		1 $\frac{5}{16}$	36.100	1.032
		1 $\frac{3}{4}$	b33.800	.973
		9/16	45.340	1.329
		15/16	b44.700	1.232
3/16	.065	5/8	40.850	1.160
		15/16	37.600	1.077
		1 $\frac{5}{16}$	b33.800	.968
		1 $\frac{3}{4}$		
		3/4	44.485	1.272
		15/16	44.485	1.290
1/4	.065	1 $\frac{5}{16}$	38.900	1.104
		1 $\frac{3}{4}$	35.350	1.022

<sup>a</sup>Data for  $\frac{b_s}{t_s} = 25$  is from reference 2.

<sup>b</sup>Average of two tests.

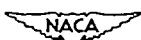


TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink, h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\sigma_f$ (ksi)	$\frac{P_f}{L\sqrt{\delta}}$ (ksi)
$t_B = 0.064 \text{ in.}; b_B = 1.60 \text{ in.}; L = 12.80 \text{ in.}; W = 8.64 \text{ in.}; b_W = 1.60 \text{ in.}; b_F = 0.64 \text{ in.};$ $\frac{t_W}{t_B} = 1.00; \frac{b_B}{t_B} = 25; \frac{b_W}{t_W} = 25$				
1/16	0.035	3/16	43.300	1.051
		3/8	41.500	1.010
		5/8	38.670	.945
		15/16	37.880	.920
		1 $\frac{5}{16}$	32.790	.801
		1 $\frac{3}{4}$	26.850	.665
3/32	.040	9/32	43.290	1.054
		3/8	42.070	1.031
		5/8	41.760	1.020
		15/16	39.340	.958
		1 $\frac{5}{16}$	34.580	.844
		1 $\frac{3}{4}$	30.200	.751
1/8	.050	3/8	42.720	1.042
		5/8	42.640	1.042
		15/16	39.140	.953
		1 $\frac{5}{16}$	35.970	.876
		1 $\frac{3}{4}$	31.920	.795
5/32	.060	15/32	43.610	1.060
		5/8	43.450	1.053
		15/16	40.220	.977
		1 $\frac{5}{16}$	36.420	.882
		1 $\frac{3}{4}$	33.760	.825
3/16	.065	9/16	41.910	1.023
		5/8	42.980	1.048
		15/16	40.950	.996
		1 $\frac{5}{16}$	36.510	.878
		1 $\frac{3}{4}$	33.480	.814
1/4	.065	3/4	41.230	1.002
		15/16	40.210	.975
		1 $\frac{5}{16}$	37.540	.906
		1 $\frac{3}{4}$	33.310	.810



TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink, h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\sigma_f$ (ksi)	$\frac{P_1}{L/\sqrt{c}}$ (ksi)
$t_B = 0.064 \text{ in.}; b_B = 1.60 \text{ in.}; L = 15.66 \text{ in.}; W = 8.64 \text{ in.}; b_W = 1.92 \text{ in.}; b_F = 0.77 \text{ in.};$ $\frac{t_W}{t_B} = 1.00; \frac{b_S}{t_B} = 25; \frac{b_W}{t_W} = 30$				
1/16	0.035	3/16	39.790	.596
		3/8	38.810	.675
		5/8	37.450	.842
		15/16	35.390	.791
		1 $\frac{5}{16}$	31.830	.710
		1 $\frac{3}{4}$	25.360	.568
3/32	.040	9/32	39.040	.880
		3/8	39.250	.890
		5/8	38.580	.872
		15/16	37.470	.841
		1 $\frac{5}{16}$	34.640	.777
		1 $\frac{3}{4}$	29.290	.658
1/8	.050	3/8	39.700	.901
		5/8	38.970	.878
		15/16	37.990	.849
		1 $\frac{5}{16}$	34.940	.783
		1 $\frac{3}{4}$	30.180	.676
		15/32	39.320	.887
5/32	.060	5/8	39.190	.887
		15/16	37.850	.847
		1 $\frac{5}{16}$	36.730	.827
		1 $\frac{3}{4}$	31.420	.701
		9/16	39.390	.865
		15/16	39.250	.858
3/16	.065	15/16	38.020	.854
		1 $\frac{5}{16}$	37.110	.838
		1 $\frac{3}{4}$	32.380	.729
		3/4	37.950	.856
		15/16	37.530	.843
		1 $\frac{5}{16}$	36.830	.830
1/4	.065	1 $\frac{3}{4}$	33.140	.746



TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\sigma_f$ (ksi)	$\frac{P_1}{L/\sqrt{\delta}}$ (ksi)
$t_g = 0.064 \text{ in.}; b_g = 1.60 \text{ in.}; L = 20.85 \text{ in.}; W = 8.64 \text{ in.}; b_W = 2.56 \text{ in.}; b_p = 1.02 \text{ in.};$ $\frac{t_W}{t_g} = 1.00; \frac{b_g}{t_g} = 25; \frac{b_W}{t_W} = 40$				
1/16	0.035	3/16	30.940	0.609
		3/8	29.930	.559
		5/8	28.830	.567
		15/16	26.530	.518
		1 $\frac{5}{16}$	25.170	.496
		1 $\frac{3}{16}$	23.640	.477
		1 $\frac{1}{4}$		
3/32	.040	9/32	31.040	.638
		3/8	31.110	.623
		5/8	30.370	.598
		15/16	28.180	.554
		1 $\frac{5}{16}$	26.870	.530
		1 $\frac{3}{16}$	25.060	.502
		1 $\frac{1}{4}$		
1/8	.050	3/8	31.900	.636
		5/8	30.490	.602
		15/16	29.040	.568
		1 $\frac{5}{16}$	27.100	.543
		1 $\frac{3}{16}$	25.900	.524
		1 $\frac{1}{4}$		
		15/32	31.780	.638
5/32	.060	5/8	31.880	.624
		15/16	29.780	.596
		1 $\frac{5}{16}$	29.300	.579
		1 $\frac{3}{16}$	26.470	.529
		1 $\frac{1}{4}$		
		9/16	31.990	.628
		5/8	31.150	.613
3/16	.065	15/16	30.770	.607
		1 $\frac{5}{16}$	28.840	.568
		1 $\frac{3}{16}$	26.170	.514
		1 $\frac{1}{4}$		
		3/4	31.880	.642
		15/16	30.490	.598
		1 $\frac{5}{16}$	29.220	.576
1/4	.065	1 $\frac{3}{16}$	27.110	.530
		1 $\frac{1}{4}$		



TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_1}{L/\sqrt{c}}$ (ksi)
$t_B = 0.064 \text{ in.}; b_B = 1.60 \text{ in.}; L = 26.04 \text{ in.}; W = 8.64 \text{ in.}; b_W = 3.20 \text{ in.}; b_F = 1.28 \text{ in.};$ $\frac{t_W}{t_B} = 1.00; \frac{b_B}{t_B} = 25; \frac{b_W}{t_W} = 50$				
1/16	0.035	3/16	27.660	0.520
		3/8	26.860	.503
		5/8	25.390	.474
		15/16	23.160	.434
		15/16	22.320	.421
		1 1/4	19.510	.368
3/32	.040	9/32	27.980	.536
		3/8	27.560	.525
		5/8	27.130	.510
		15/16	25.190	.472
		15/16	23.740	.446
		1 1/4	21.030	.396
1/8	.050	3/8	27.720	.521
		5/8	27.480	.516
		15/16	26.530	.503
		5/16	25.200	.475
		1 1/4	21.690	.409
5/32	.060	15/32	28.230	.542
		5/8	28.400	.544
		15/16	27.350	.515
		5/16	25.780	.485
		1 1/4	23.000	.435
3/16	.065	9/16	28.060	.527
		5/8	27.540	.517
		15/16	26.830	.502
		5/16	25.560	.480
		1 1/4	23.240	.437
1/4	.065	3/4	28.010	.528
		15/16	27.310	.508
		5/16	26.440	.496
		1 1/4	24.340	.460



TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_1}{L/\sqrt{c}}$ (ksi)
$t_S = 0.102 \text{ in.}; b_S = 2.55 \text{ in.}; L = 9.44 \text{ in.}; W = 13.39 \text{ in.}; b_W = 1.28 \text{ in.}; b_F = 0.51 \text{ in.}$				
$\frac{t_W}{t_S} = 0.63; \frac{b_S}{t_S} = 25^a; \frac{b_W}{t_W} = 20$				
3/32	0.050	9/32	42.300	1.412
		9/16	39.300	1.288
		7/8	38.170	1.218
		17/32	35.400	1.158
		19/32	34.500	1.129
		2	30.000	.984
1/8	.060	3/8	43.800	1.445
		9/16	40.400	1.321
		7/8	39.700	1.263
		17/32	37.800	1.237
		19/32	35.500	1.167
		2	30.240	.984
5/32	.070	15/32	b43.590	1.431
		9/16	b42.335	1.388
		7/8	41.050	1.310
		17/32	37.850	1.236
		19/32	35.750	1.168
		2	31.800	1.049
3/16	.080	9/16	b45.150	1.451
		7/8	a41.150	1.327
		17/32	38.800	1.263
		19/32	38.150	1.253
		2	31.900	1.042
		3/4	b44.050	1.471
1/4	.090	7/8	b43.000	1.378
		17/32	40.700	1.329
		19/32	39.800	1.307
		2	34.100	1.120

<sup>a</sup>Data for  $\frac{b_S}{t_S} = 25$  is from reference 2.

<sup>b</sup>Average of two tests.

<sup>c</sup>Average of three tests.

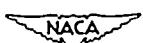


TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, <i>d</i> (in.)	Depth of countersink <i>h</i> (in.)	Pitch of rivets, <i>p</i> (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_f}{L/\sqrt{d}}$ (ksi)
$t_g = 0.102 \text{ in.}; b_g = 2.55 \text{ in.}; L = 11.64 \text{ in.}; W = 13.39 \text{ in.}; b_W = 1.60 \text{ in.}; b_F = 0.64 \text{ in.};$ $\frac{t_W}{t_g} = 0.63; \frac{b_g}{t_g} = 25; \frac{b_W}{t_W} = 25$				
3/32	0.050	9/32	42.800	1.106
		9/16	40.550	1.049
		7/8	39.100	.990
		17/32	36.210	.938
		19/32	35.480	.925
		2	29.890	.754
1/8	.060	3/8	42.650	1.102
		9/16	41.910	1.078
		7/8	40.190	1.034
		17/32	39.060	1.005
		19/32	36.500	.947
		2	34.150	.891
5/32	.070	15/32	43.550	1.128
		9/16	43.120	1.118
		7/8	40.550	1.033
		17/32	40.510	1.051
		19/32	37.470	.987
		2	33.800	.874
3/16	.080	9/16	42.170	1.069
		7/8	40.340	1.041
		17/32	39.780	1.030
		19/32	37.390	.958
		2	33.850	.872
		3/4	42.960	1.123
1/4	.090	7/8	41.890	1.080
		17/32	40.560	1.049
		19/32	37.420	.967
		2	34.380	.899



TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_1}{L/\sqrt{c}}$ (ksi)
$t_S = 0.102 \text{ in.}; b_S = 2.55 \text{ in.}; L = 14.52 \text{ in.}; W = 13.39 \text{ in.}; b_W = 1.92 \text{ in.}; b_F = 0.77 \text{ in.};$ $\frac{t_W}{t_S} = 0.63; \frac{b_S}{t_S} = 25; \frac{b_W}{t_W} = 30$				
3/32	0.050	9/32	39.410	0.900
		9/16	37.690	.841
		7/8	36.090	.800
		17/32	35.060	.778
		19/32	32.850	.733
		2	30.400	.672
1/8	.060	3/8	39.800	.887
		9/16	38.960	.874
		7/8	37.780	.845
		17/32	36.000	.805
		19/32	33.960	.754
		2	33.460	.742
5/32	.070	15/32	39.970	.888
		9/16	39.110	.868
		7/8	37.850	.836
		17/32	37.860	.845
		19/32	35.990	.803
		2	33.290	.753
3/16	.080	9/16	38.210	.838
		7/8	37.910	.841
		17/32	37.070	.829
		19/32	36.080	.803
		2	33.290	.741
1/4	.090	3/4	39.840	.883
		7/8	39.400	.871
		17/32	38.220	.845
		19/32	36.570	.814
		2	33.930	.754



TABLE 2. - NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_1}{L/\sqrt{c}}$ (ksi)
$t_B = 0.102 \text{ in.}; b_B = 2.55 \text{ in.}; L = 20.00 \text{ in.}; W = 13.39 \text{ in.}; b_W = 2.56 \text{ in.}; b_F = 1.02 \text{ in.};$				
3/32	0.050	$\frac{t_W}{t_B} = 0.63; \frac{b_B}{t_B} = 25; \frac{b_W}{t_W} = 40$	9/32	32.850
			9/16	30.840
			7/8	28.810
			1 $\frac{7}{32}$	28.010
			1 $\frac{19}{32}$	26.500
			2	25.700
1/8	.060		3/8	32.910
			9/16	32.850
			7/8	30.500
			1 $\frac{7}{32}$	29.580
			1 $\frac{19}{32}$	27.960
			2	26.610
5/32	.070		15/32	32.820
			9/16	32.750
			7/8	31.610
			1 $\frac{7}{32}$	30.560
			1 $\frac{19}{32}$	29.110
			2	28.080
3/16	.080		9/16	33.440
			7/8	32.140
			1 $\frac{7}{32}$	30.920
			1 $\frac{19}{32}$	29.510
			2	27.930
1/4	.090		3/4	33.110
			7/8	33.380
			1 $\frac{7}{32}$	32.110
			1 $\frac{19}{32}$	31.130
			2	30.270



TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Concluded

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_f}{L/\sqrt{c}}$ (ksi)
$t_g = 0.102 \text{ in.}; b_g = 2.55 \text{ in.}; L = 25.70 \text{ in.}; W = 13.39 \text{ in.}; b_W = 3.20 \text{ in.}; b_F = 1.28 \text{ in.};$				
		$\frac{t_W}{t_g} = 0.63; \frac{b_g}{t_g} = 25; \frac{b_W}{t_W} = 50$		
3/32	0.050	9/32 9/16 7/8 $1\frac{7}{32}$ $1\frac{19}{32}$ 2	29.500 27.880 25.590 23.540 22.290 21.670	0.474 .444 .405 .327 .354 .343
1/8	.060	3/8 9/16 7/8 $1\frac{7}{32}$ $1\frac{19}{32}$ 2	30.170 29.190 27.220 26.750 24.000 23.450	.481 .465 .432 .425 .378 .378
5/32	.070	15/32 9/16 7/8 $1\frac{7}{32}$ $1\frac{19}{32}$ 2	30.170 29.820 29.000 27.110 25.670 24.600	.479 .474 .462 .433 .409 .394
3/16	.080	9/16 7/8 $1\frac{7}{32}$ $1\frac{19}{32}$ 2	29.350 28.880 27.650 26.070 24.650	.466 .458 .441 .415 .393
1/4	.090	3/4 7/8 $1\frac{7}{32}$ $1\frac{19}{32}$ 2	31.380 29.520 29.230 27.450 26.640	.502 .462 .468 .434 .427



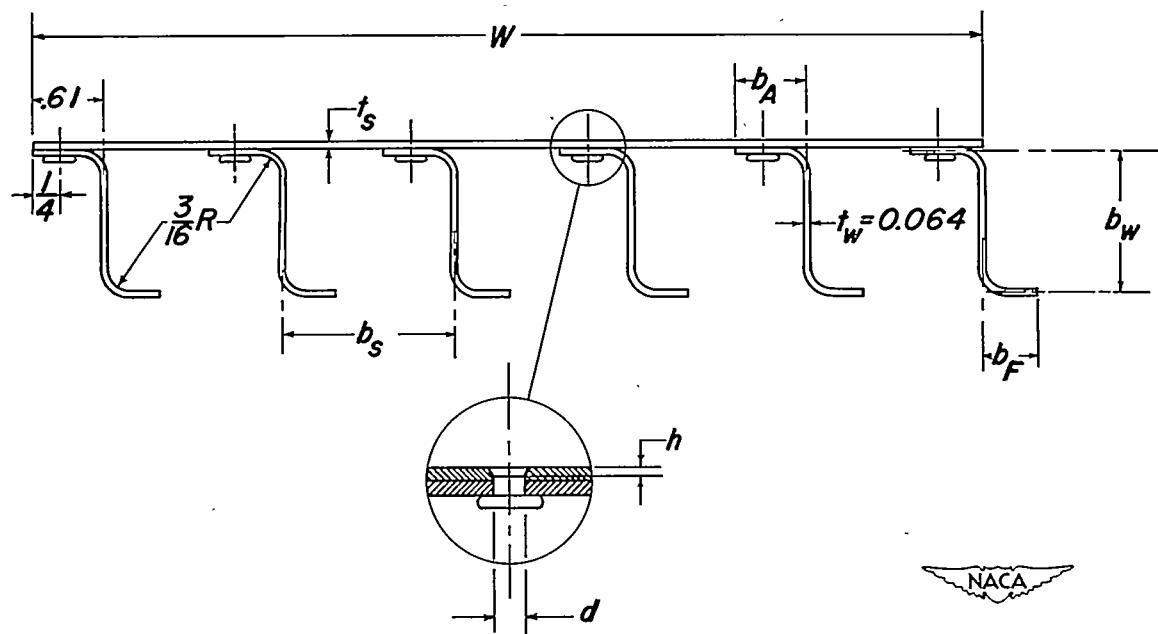
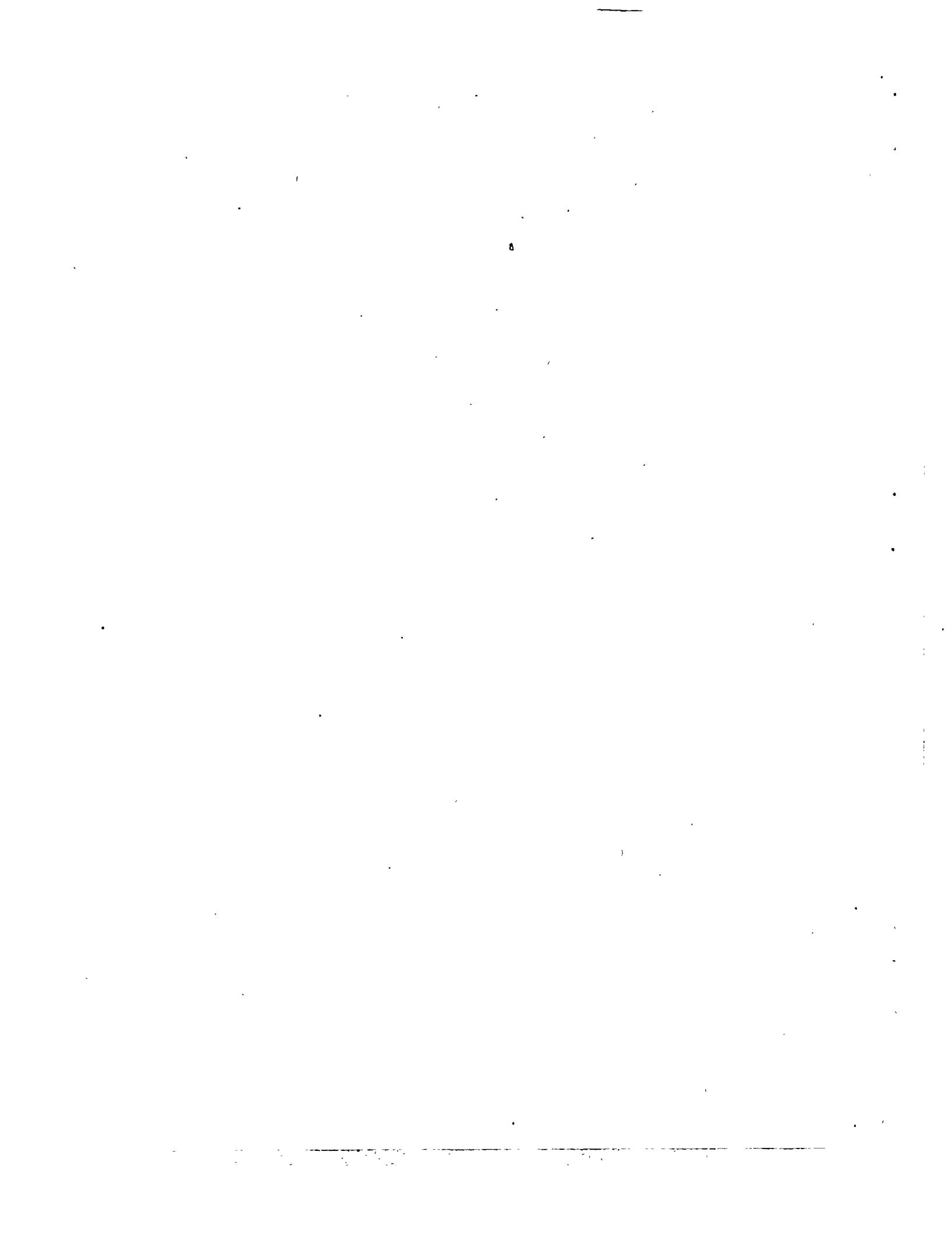


Figure 1.— Cross section of test specimens.



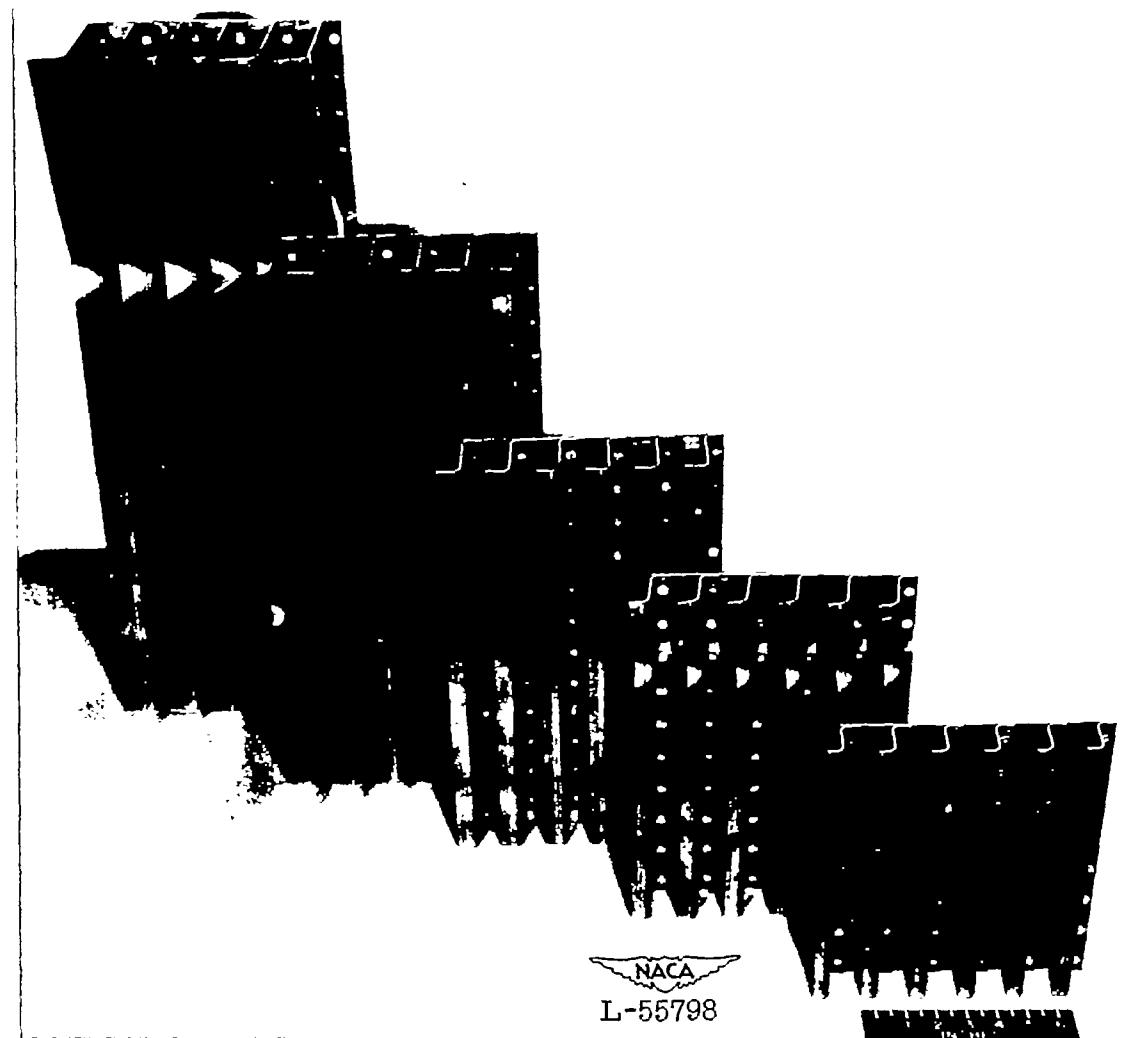


Figure 2.- Typical specimens after failure.

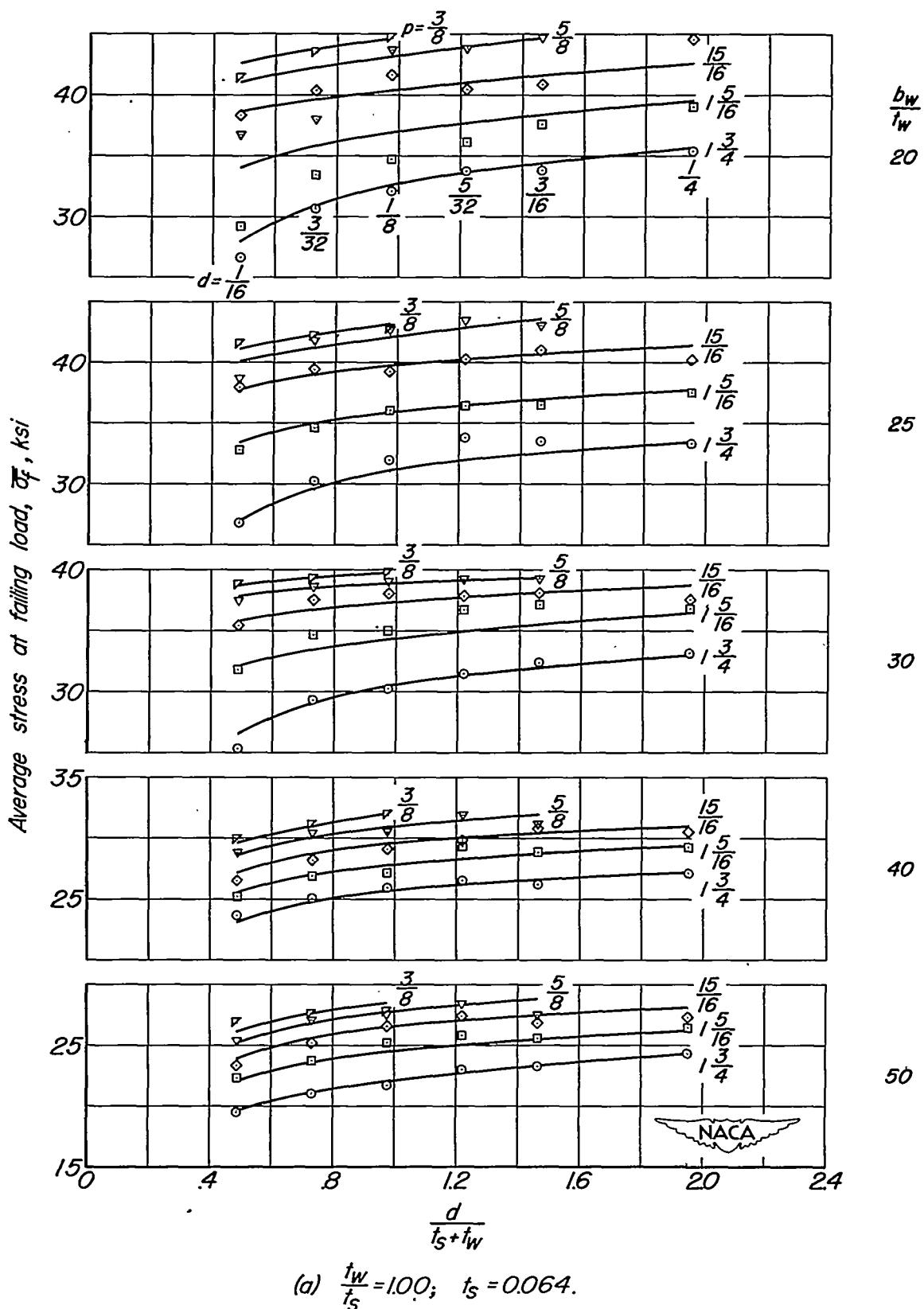


Figure 3.—Variation in compressive strength of panels with rivet diameter.

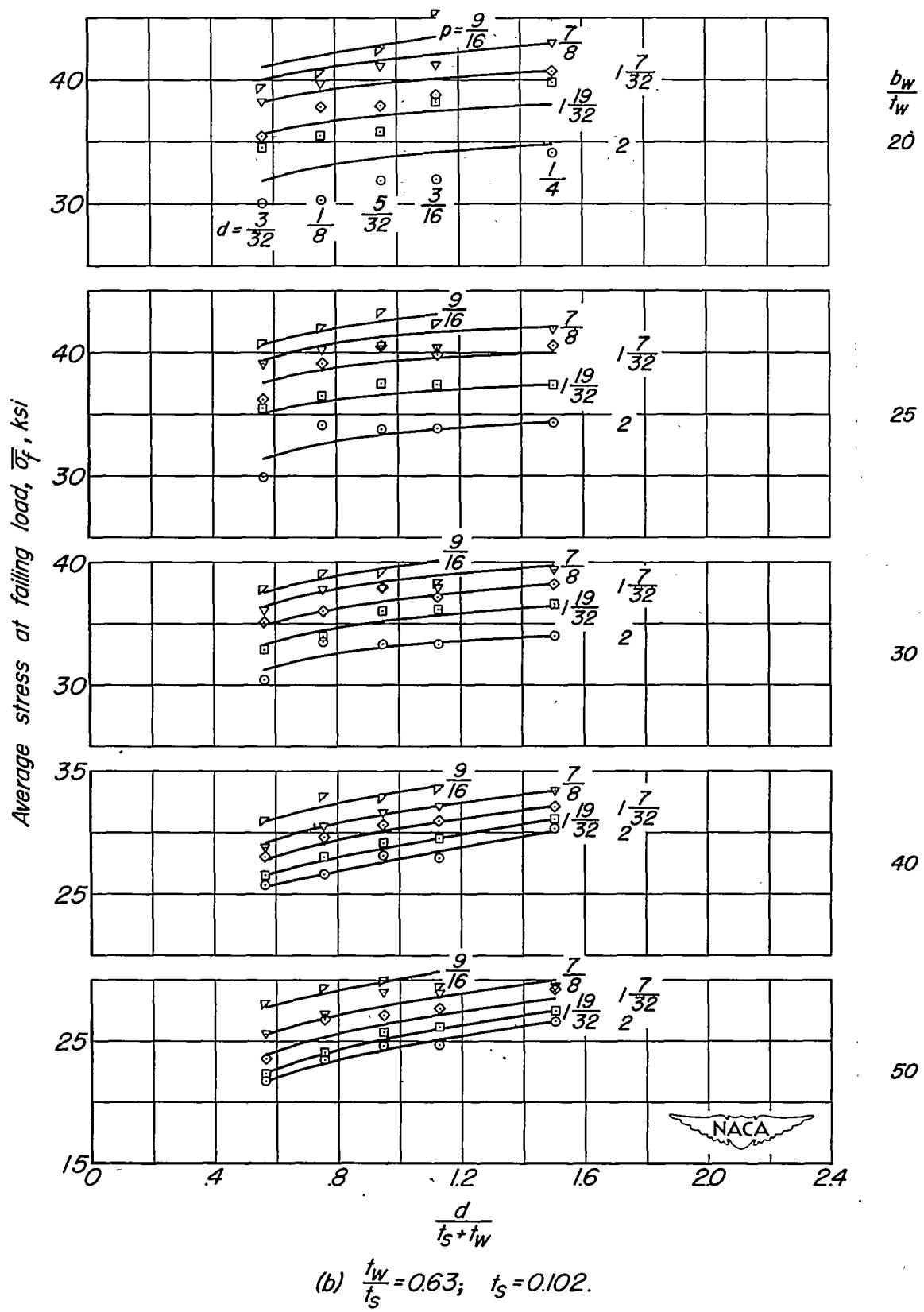


Figure 3-Concluded.